

*On the Nature of the Movement of the Chromatophores of Cephalopods.* By M. C. PHISALIX.

It is stated by P. Bert, in his important memoir on the physiology of the cuttle, that the movement of the chromatophores is due to dilatatory muscles with rapid contractile power. MM. Pelvet and Frédérick were the first to support this view with experiments. Another theory, which owes its origin to anatomical observations, considers these movements to be of an amœboid nature. It was advanced by Harting, and has been maintained by MM. Raphaël Blanchard, P. Girod, and quite recently by M. Joubin. However, the latter author reconciled the theories by admitting the former for the young and the latter for the adult chromatophore, and, as a corollary, the *transformation of muscular into connective fibres*.

The theory of P. Bert is the only rational one. It was to demonstrate the justice of it that I undertook a series of investigations at the zoological station of Arcachon, where, thanks to MM. Viallanes and Jolyet, I found the material necessary for my task.

Three kinds of movements are distinguishable in the chromatophores.

1. *Tremulous movements*.—In a living Cephalopod, in a state of rest, the chromatophores are constantly agitated by little shocks, which are scarcely visible; it is like an incessant and rapid trembling, and this gives the skin of Cephalopods its characteristic appearance. These movements are under the control of the nervous system; they disappear as soon as the pallial nerve is divided or the chromato-motor centres are injured. In that case the chromatophores diminish still further in diameter and the skin attains its maximum degree of paleness.

2. *Undulating movements*.—These do not set in, as a general rule, until after death. They consist in the maximum expansion followed by the contraction of the chromatophores. Their characteristic feature is that they commence at one or several points and radiate thence in all directions, to reproduce themselves in an irregular and disordered fashion. They are due to the direct stimulation of the skin, and persist for a long time after death.

3. *Movements of functional activity*.—These occur in the living animal only, and serve it as a means of defence. They are the result of reflex actions, which depend entirely on the central nervous system. Accordingly the section of the pallial nerve at the neck suffices to render them impossible in the portion of the body innervated by this nerve. The galvanization of the peripheral extremity of this nerve provokes the dilatation of the chromatophores, which remain in a state of expansion so long as the stimulus continues. It is a veritable *tetanzation*. It is produced and ceases *simultaneously* with that of the muscles of the mantle. A single stimulus induces a transitory dilatation, which appears and terminates *simultaneously* with the muscular shock.

*Chromato-motor nervous centres*.—If we stimulate the central extremity of the pallial nerve we obtain the dilatation of the chromatophores of the opposite side. The centre of the reflex actions is

therefore situated at the actual origin of these nerves. We can determine their seat by experiment. By inflicting localized injuries, either with red-hot iron or the scalpel, I have arrived at the following results:—

*Sub-oesophageal centres.*—The destruction of the median sub-oesophageal lobe causes the paralysis of the chromatophores on the entire surface of the body, which remains absolutely pale. If the injury has only affected one side the paralysis likewise takes place on one side only, but on that opposite to the injury. There is therefore a manifest *crossing* of the nervous fibres in the thickness of the ganglion.

*Supra-oesophageal centres.*—The removal of the cerebral calotte has no effect on the action of the chromatophores, provided that the injury does not extend to the optic nerves. If, on the other hand, the red-hot needle has reached the level of the optic nerve, it produces, simultaneously with the dilatation of the pupil, the paralysis of the chromatophores of the injured side. It therefore appears that the chromatophores are under the influence of two centres, one for direct effects, the other for those which take place on the opposite side. After the destruction of the former it often happens that the chromatophores of the opposite side remain in a state of permanent dilatation. Now we know that in the normal condition the sensation in the Cephalopods may be expressed by the dilatation of the chromatophores and the intensely black coloration of the skin, or else by their maximum contraction and an extreme pallor. Are these two phenomena regulated by two different centres, a chromato-dilator and a chromato-constrictor? I have not succeeded in completely elucidating this point by experiments.

*Excitability of the centres.*—This is demonstrated by direct stimulation. We can also operate upon it and modify it by physiological means: thus, it rapidly disappears after copious hæmorrhage, and insensibly diminishes in animals enfeebled by starvation and a sojourn in the aquarium. It increases under the influence of certain poisons. Strychnine and curari act upon it in a characteristic fashion: at each convulsive shock the chromatophores behave like the muscle: their expanding movement commences and ceases *simultaneously* with the muscular shock.

*Form and characteristics of the movement.*—The movement of the chromatophore is divisible into two stages:—(1) expansion, (2) contraction. In an enfeebled animal the difference of duration between the two stages is so accentuated that we can register it in an indirect fashion, and in this way, by a special arrangement, I have obtained outlines which are as approximate as possible. If we compare these outlines with those of the contraction of the muscles of the mantle we find a striking resemblance.

*The radial fibres are muscles.*—Of all the characters which have just been enumerated there is not one which cannot be referred to the properties of rapidly contractile muscles: it is, moreover, necessary to eliminate from henceforth the slowly contractile muscles of the skin. The peristaltic movements which are centred in the latter

are neither synchronous nor homologous with those of the chromatophore. The cause of the active movement of the chromatophore resides exclusively in the radial fibres. This is directly demonstrable by means of a crucial experiment.

If we completely destroy the centre of a chromatophore with a needle, so as to leave only the periphery intact, the movements of expansion and contraction continue to take place in this intact portion. If, on the other hand, we destroy the radial fibres by a circular lesion, leaving the cell intact, the movements are completely abolished. It is, on the contrary, the central or coloured portion of the chromatophore which, by the influence of its elasticity, exercises the active rôle in the stage of contraction. This elasticity is easily displayed; a gentle pressure on the centre of a chromatophore is sufficient to flatten it and spread it out; but as soon as the pressure is removed the organ resumes its spherical shape.

To sum up our results: the chromatophore of the Cephalopods is an elastic pigmented sphere, the expansive movements of which are determined by the contraction of muscles arranged radially at its equator, and which reverts to the spherical shape as soon as the contraction has ceased.—*Comptes Rendus*, t. exiii. no. 16 (Oct. 19, 1891), pp. 510–512.

*On the Anatomy of the Male Sexual Organs of the Honey-Bee.*

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In my investigations into the structure of the male sexual apparatus of the honey-bee I arrived at the following results.

All existing figures and descriptions of the male sexual apparatus of the honey-bee in zoological and apicultural literature are either incomplete or incorrect. The testis of the bee has two envelopes. The external one, formed by the fat-body, has two kinds of cells—(1) large and flat, with elongated flattened nuclei; (2) irregularly spherical, which are entirely similar to the cells of the fat-body containing fat-globules. The second inner envelope is of the nature of connective tissue, and two layers are to be distinguished in it. In the outer layer we find large cells with oval nuclei, and the inner layer is finely fibrillar, with spindle-shaped nuclei.

The seminal tubules are surrounded by a delicate fibrillar envelope, containing elongated nuclei, and open into a reservoir in the interior of the testis, which is clothed with epithelium. This epithelium enters slightly into the orifice of each separate seminal tubule.

The tracheæ, which everywhere penetrate the testicular envelopes, ramify in the interior of the testis between the several seminal tubules. The belief (Cholodkowsky) that in butterflies there are no tracheæ within the testis is erroneous.

The entire testis of the bee corresponds to only a section of the testis of such a type as, *e. g.*, in *Bombyx mori*. The reservoir, into which all seminal tubules open, is enveloped in a thick membrane